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On the Method of Horizontal Comparison in the Location of Spectra of Elements—II.

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In a previous paper,[1] a new method has been formulated for locating the spectra of elements. Successive elements, *e.g.*,

A. I-B, C, N,...etc. ; II C^+, N^+, O^+,...etc.; III etc.
B. I-Al, Si, ...etc. ; II Si^+, P^+. ...etc.; III etc.

are taken and it has been shown that the average frequencies of the elements in any such group arising from the transition $xL_2(M_1 \leftarrow M_2)$ for 'A' and to $xM_2(N_1 \leftarrow N_2)$ for 'B' progress linearly with the atomic number. This enables us to locate the spectrum of an unclassified element in a group. In the present paper we shall discuss the spectra of the same elements arising from the transitions $xL_2(M_2 \leftarrow M_3)$ and xM_2 $(N_2 \leftarrow N_3)$ for the groups in 'A' and 'B' respectively.

It is evident that the spectra are, in the present case, more complex. Even if we limit our choice to the highest

[1] Saha and Majumdar, Ind. Journ. Phys., 3, 67 (1928).

multiplicity lines as before, we find that with most of the elements there are nine multiplets, whereas in the previous case there were only three. For an example we take the II group in 'A'. The expected terms (of highest multiplicity) due to the configurations xL_2M_2 and xL_2M_3 of the elements of this group are shown in table I. Any other such group will,

TABLE I.

		Terms	
X	Element	xL_2M_3	xL_1M
0	C^+	^2P	^2D
1	N^+	$^3D\,^3P\,^3S$	$^3F\,^3D\,^3P$
2	O^+	$^4D\,^4P\,^4S$	$^4F\,^4D\,^4P$
3	F^+	^5P	^5D
4	Ne^+	$^4D\,^4P\,^4S$	$^4F\,^4D\,^4P$
5	Na^+	$^3D\,^3P\,^3S$	$^3F\,^3D\,^3P$
6	Mg^+	^2P	^2D

however, give similar terms. It will be seen that the elements N^+, O^+, Ne^+ and Na^+ of this group, or for the matter of that, elements having 1, 2, 4, and 5 as the values of x, will each give rise to nine multiplets. This fact is represented in Fig. 1 the combinations being denoted by circles.

M_3' / M_3	F	D	P
D	⊙	O	O
P	O	⊙	O
S	O	O	⊙

Fig. 1.

TABLE II.

$xL_2(M_2 \leftarrow M_3)$.

X→	0	1	2	3	4	5	6
(1)		$^3P_2-{}^3D_3$	$^4P_3-{}^4D_4$		$^4S_2-{}^4P_3$	$^3P_2-{}^3D_3$	
(2)	$^3P_2-{}^3D_3$	$^3S_1-{}^3P_2$	$^4D_4-{}^4F_5$	$^3P_2-{}^3D_4$	$^4D_4-{}^4F_5$	$^3D_3-{}^3F_4$	$^3P_2-{}^3D^4$
(3)		$^3D_3-{}^3F_4$	$^4S_2-{}^4P_3$		$^4P_3-{}^4D_4$	$^3S_1-{}^3P_2$	
I	B	C	N	O	F	Ne	Na
(1)						10843	
(2)	8700	[9700]	[10400]	10788	[11400]	11933	12199
(3)						13350	
II	C^+	N^+	O^+	F^+	Ne^+	Na^+	Mg^+
(1)		16826	24270		29045		
(2)	13816	19965	24528	28516	31064	33000	35729
(3)		19974	26731		32945		
III	N^{++}	O^{++}	$O^{+\times}$	Ne^{++}	Na^{++}	Mg^{++}	Al^{++}
(I)		26910	38692				
(2)	21543	31911	38461	46200	[51700]	[56900]	62037
(3)		30615	33355				

B Extrapolated from Sawyer, Naturwissenschaft, 192.

F^{++} Dingle, Proc. Roy. Soc., 122, 144 (1929).

Ne^{++} Identified by the author from Dr. Ganesan's data, Phys. Rev., Vol. 32.

Some of these multiplets, *viz.*, PF, SF, SD are, however, very weak and in many of the elements have not been obtained at all. For convenience in comparison we have chosen only the three chief multiplets, *viz.*, DF, PD, and SP, shown in the above figure by means of dots within the circles. Again as before we shall take only one line—the strongest—from each of the three multiplets chosen. The wave-numbers of these lines for the respective elements are collected in tables II and III for the two sets of groups 'A' and 'B'. The sources from which these have been obtained are mostly those mentioned in the previous paper[1] and have

[1] *loc. cit.*

not been repeated ; reference has been made to those only which have not been referred to before.

The figures collected in table II are graphically represented in the accompanying diagram (fig. 2), where frequencies of lines of different groups are plotted against the elements in question.

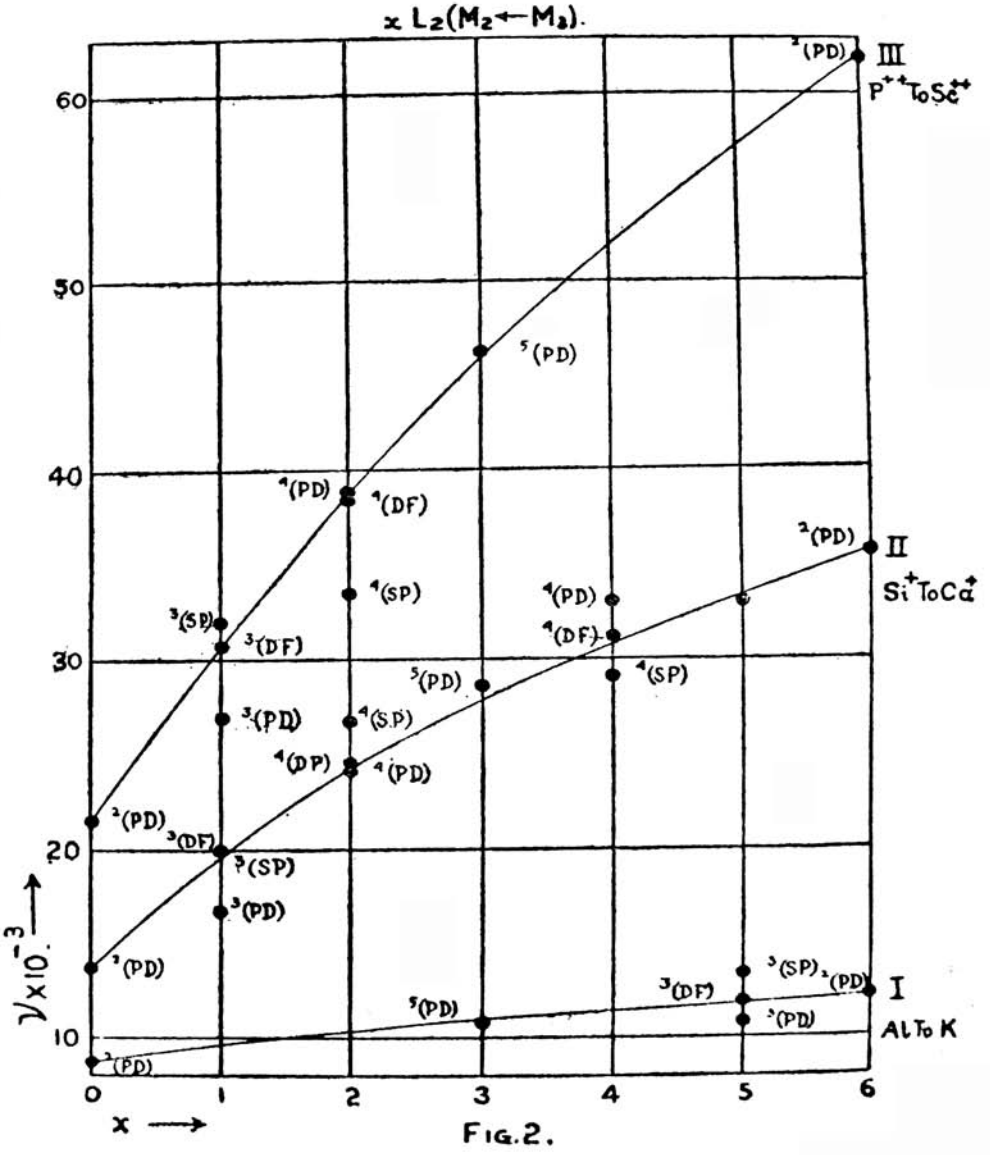

FIG. 2.

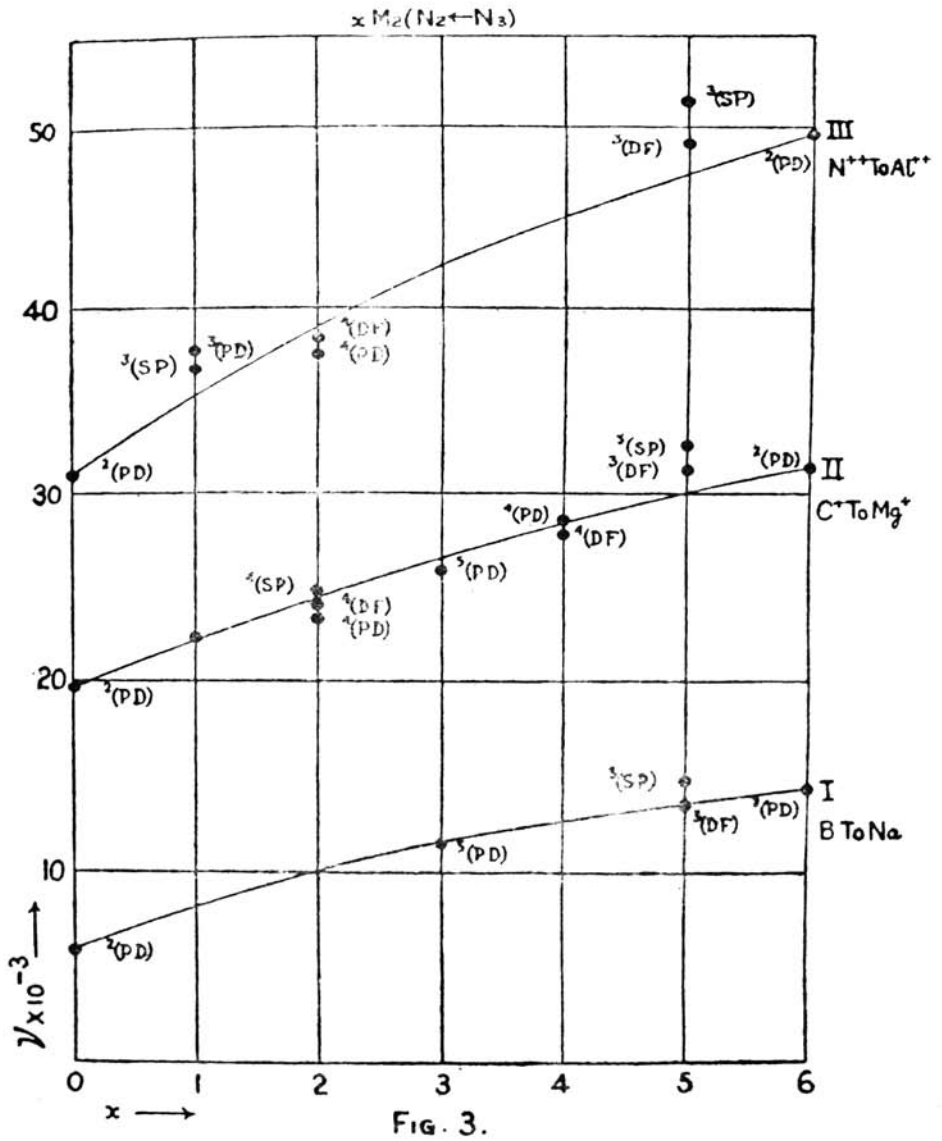

FIG. 3.

In the same way the graphs shown in fig. 3 are also drawn for the values given in table III. It will be observed that though there is a general inclination for the corresponding multiplets of the different elements to follow a linear relation, this is far from being exactly so and

the relation seems to be more complex for the transition $M_2 \leftarrow M_3$ than for $M_1 \leftarrow M_2$. Another point of difference from the graph given in the previous paper may also be noted. There the various multiplets for any particular element were more evenly distributed about the mean than in the present instance, where some irregularities are noticeable. As for instance, the ^{4}(SP) multiplet in the spectrum of O^+ is shifted

TABLE III.

$xM_2(N_z \leftarrow N_3)$.

$x \rightarrow$	0	1	2	3	4	5	6
(1)		$^3P_2 - {}^3D_3$	$^4P_3 - {}^4D_4$		$^4S_2 - {}^4P_3$	$^3P_2 - {}^3D_3$	
(2)	$^2P_2 - {}^2D_3$	$^2S_1 - {}^3P^2$	$^4D_4 - {}^4F_5$	$^5P_3 - {}^5D_4$	$^4D_4 - {}^4F_5$	$^3D_3 - {}^3F^4$	$^3P_2 - {}^4D_3$
(3)		$^3D_3 - {}^3F_4$	$^4S^2 - {}^4P_3$		$^4P_3 - {}^4D_4$	$^3S_1 - {}^3P_2$	
I	Al	Si	P	S	Cl	A	K
(1)						...	
(2)	5969	[8000]	[9900]	11517	[12600]	13561	14354
(3)	(calculated)					14804	
II	Si^+	P^+	S^+	Cl^+	A^+	K^+	Ca^+
(1)			23280		..	...	
(2)	19773	22339(?)	24016	25894	27859	31338	31444
(3)			24790		28632	32647	
III	P^{++}	S^{++}	Cl^{++}	A^{++}	K^{++}	Ca^{++}	Sc^{++}
(1)		37720	37505			...	
(2)	30916	36664	38200	[42100]	[44900]	49161	49724
(3)		...	...			51464	

S. Bungartz, Ann. d. Phys., 76, 723 (1925).
S^+ Ingram, Phys. Rev., 32, 172 (1928).
S^{++} Gilles, Comp. Ren., 188, 63 (1929).
Cl^{++} Majumdar and Deb, Ind. Journ. Phys., 3, 445 (1929).

by about 2200 frequency units towards higher frequency side from ^{4}(DF) multiplet, whereas in F^{++} it lies just the other way, about 5100 frequency units less than the ^{4}(DF) multiplet. Perhaps it would be worthwhile to look over the data for these elements once again and be sure whether the discrepancy is genuine or unreal. In spite of all these deviations, however, the graphs may be utilised with sufficient confidence for location of spectra of elements and have frequently been employed in this laboratory with invariable success. For convenience in further work the predicted positions of the spectra of some of the elements discussed in this paper, which have not been classified so far, are shown in squared brackets in tables II and III.

The author wishes to express his thanks to Prof. M. N. Saha, D.Sc., F.R.S., for his interest in this work.

Note.—In this laboratory this method has been used with success in the location and the classification of the spectra of a number of elements. Below is given a list of such works.

[1] Spectrum of Na^+, by K. Majumdar.
[2] Spectrum of Ca^{++}, by K. Majumdar.
[3] Spectrum of S^+, by D. K. Bhattacharya.
[4] Spectrum of Cl, by K. Majumdar.
[5] Spectrum of Br^{++}, Br^{+++}, Br^{+IV} by S. C. Deb.
[6] Spectrum of Rb^+, by R. C. Majumdar.
[7] Spectrum of A^{+++}, by D. S. Jog.
[8] Spectrum of P, by D. G. Dhawle.